ENDANGERED FISH MONITORING AND NONNATIVE SPECIES MONITORING AND CONTROL IN THE UPPER/MIDDLE SAN JUAN RIVER: 2013

FINAL REPORT

PREPARED FOR:

SAN JUAN RIVER BASIN RECOVERY IMPLEMENTATION PROGRAM

PREPARED BY:

BOBBY R. DURAN

U.S. FISH AND WILDLIFE SERVICE

NEW MEXICO FISH AND WILDLIFE CONSERVATION OFFICE

3800 COMMONS N.E.

ALBUQUERQUE, NM 87109

Endangered Fish Monitoring and Nonnative species Monitoring and Control in the Upper/Middle San Juan River: 2013

Prepared by:

Bobby R. Duran

Bobby_Duran@fws.gov

United States Fish and Wildlife Service

New Mexico Fish and Wildlife Conservation Office

3800 Commons N.E.

Albuquerque, NM 87109

Submitted to:

San Juan River Basin Recovery Implementation Program

Biology Committee

1 July 2014

EXECUTIVE SUMMARY

1. A total of 13,912 channel catfish and 202 common carp were removed from river miles (RM) 166.6 – 52.9 in 693.7 hours of electrofishing.

2. No juvenile channel catfish were collected during the two nonnative removal trips and fall monitoring from PNM Weir to Hogback Diversion. Adult catch rates were similar to values observed in 2012.

3. Juvenile channel catfish CPUE, from Hogback Diversion to Shiprock Bridge, declined during all three nonnative removal trips and fall monitoring. Adult channel catfish CPUE remained similar to 2012.

4. Juvenile and adult channel catfish CPUE, from Shiprock Bridge to Mexican Hat, Utah, declined during fall monitoring to the lowest observed catch rates throughout the study period 1996-2013.

5. Mean common carp CPUE was <1.0 fish/hour in all three removal sections.

6. Common carp CPUE, during annual fall monitoring in all three removal sections, significantly declined after the initiation of nonnative removal.

7. A total of 573 Colorado pikminnow and 2,041 razorback sucker were collected during our efforts in 2013.

8. Nineteen adult Colorado pikeminnow (>450 mm total length (TL)) were collected in 2013 including 15 individual fish >500 mm TL.

9. Similar to 2012, a possible spawning aggregation of adult Colorado pikeminnow was observed in June near RM 118.

10. Razorback sucker continue to show long-term persistence in the river. Fourteen individual fish captured in 2013 had been in the San Juan River 10 or more years.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The San Juan River is home to two federally endangered fishes, Colorado pikeminnow *Ptychocheilus lucius* and razorback sucker *Xyrauchen texanus.* The establishment of channel catfish *Ictalurus punctatus* and common carp *Cyprinus carpio* has been identified as a detriment to the recovery of Colorado pikeminnow and razorback sucker (USFW 2002a, b). Reducing the impacts of nonnative fishes has specifically been identified as a management element in the San Juan River Basin Recovery Implementation Program's Long Range Plan (U.S. Fish and Wildlife Service 2013):

Element 3 - Specific goals, actions, and tasks

Goal 3.1 Control Problematic Nonnative Fishes.

Action 3.1.1 Develop, implement, and evaluate the most effective strategies for reducing problematic nonnative fish.

Task 3.1.1.1 Mechanically remove nonnative fish to achieve objectives

Removal efforts by U.S. Fish and Wildlife Service, New Mexico Fish and Wildlife Conservation Office (NMFWCO) began on a limited basis in 1998 with intensified efforts beginning in 2001. These initial efforts focused on a section of river from PNM Weir to Hogback Diversion (RM 166.6 - 159.0). In addition to this section, intensive nonnative removal from Hogback Diversion to Shiprock Bridge (RM 158.8 – 147.9) has been conducted since 2003. Based on observed increases in channel catfish abundance (Ryden 2007, 2008), efforts were expanded in 2008 to include intensive removal from Shiprock Bridge to Mexican Hat, UT (RM 147.9 – 52.9). In 2013, intensive nonnative removal conducted by NMFWCO encompassed 113.7 river miles.

Study objectives were as follows:

1. Continue to remove nonnative fishes, primarily channel catfish and common carp, from 113.7 river miles of the San Juan River
2. Implement riverwide mark/recapture to determine exploitation rates for channel catfish
3. Evaluate distribution and abundance patterns of nonnative species to determine effects of mechanical removal
4. Characterize distribution and abundance of endangered fishes in the upper and middle reaches of the San Juan River

STUDY AREA

Intensive nonnative removal efforts in 2013 focused on three individual sections of the San Juan River, New Mexico, Colorado, and Utah, encompassing 113.7 river miles (RM). Sections sampled included PNM Weir to Hogback Diversion (RM 166.6 – 159.0), Hogback Diversion to Shiprock Bridge (RM 158.8 – 147.9), and Shiprock Bridge to Mexican Hat, Utah

(RM 147.9 – 52.9) (Figure 1). Nonnative removal was conducted in several portions of Geomorphic reaches (Bliesner and Lamarra 2000). PNM Weir to Hogback Diversion was exclusively located in Geomorphic Reach 6, Hogback Diversion to Shiprock Bridge encompassed portions of both Geomorphic reaches 6 and 5, and Shiprock Bridge to Mexican Hat was in reaches 5 – 2.

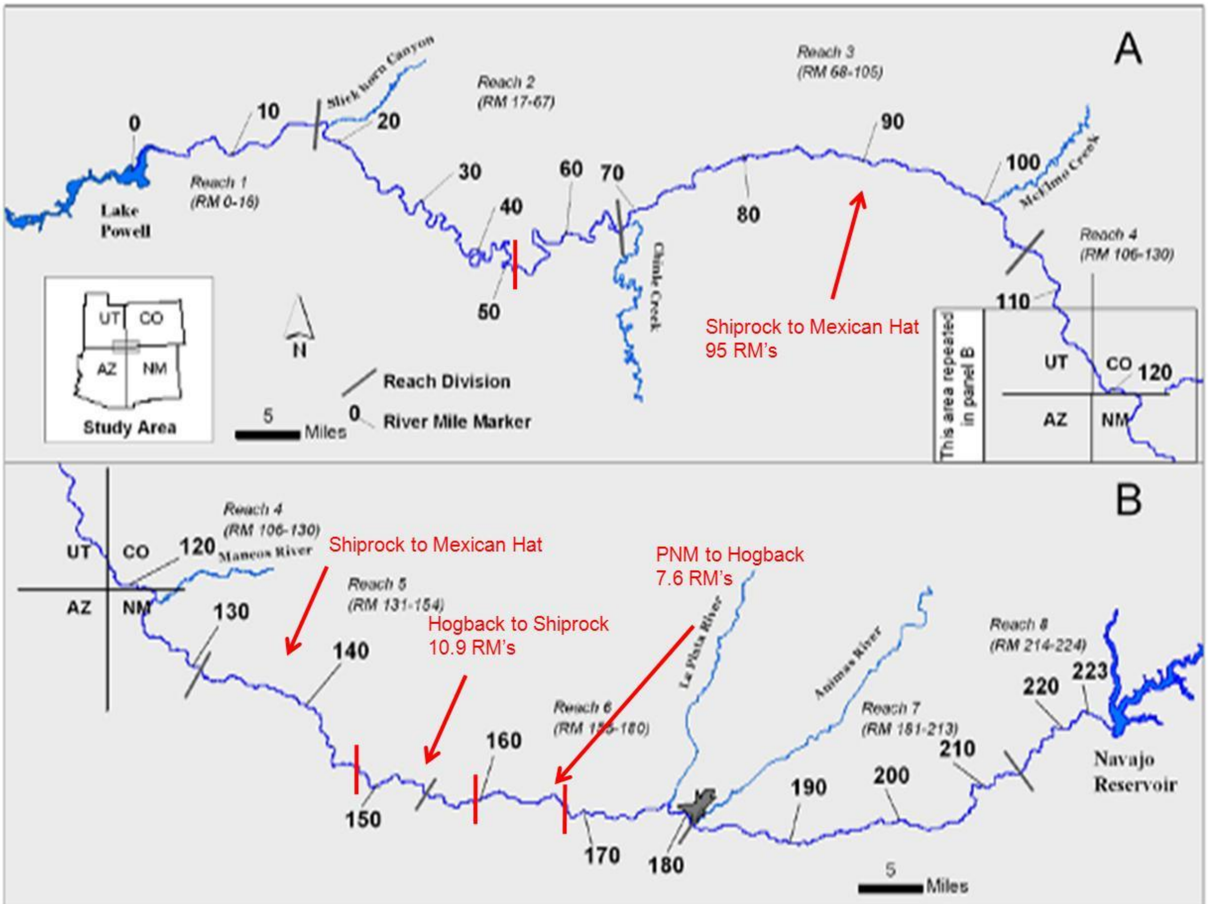

Figure 1. Map of study area – map provided by UNM MSB

METHODS

Nonnative fishes were collected using raft-mounted electrofishing units (Smith-Root 5.0 GPP). Electrofishing settings were standardized to run pulsed direct current (PDC) on high range. Percent of power was adjusted by raft operators to maintain an output current of 4 amperes. Rafts sampled near each shoreline and netters attempted to collect any nonnative fishes observed. In addition to nonnative species, native rare fishes were netted during all efforts. Electrofishing proceeded downstream and fish were processed at designated stops.

All nonnative fishes or a representative sub-sample (blind grab) were measured (nearest 1 mm) for total (TL) and standard length (SL) and weighed (nearest 5 g). Seconds of electrofishing were recorded to determine effort at the end of each sampling unit. Sampling units ranged from two to three miles depending on the section. All nonnative fishes collected were removed from the river. Two electrofishing rafts sampled for three consecutive days/trip from PNM Weir to Hogback Diversion and Hogback Diversion to Shiprock Bridge. During sampling from Shiprock Bridge to Mexican Hat, a total of four electrofishing rafts were used. Two rafts began sampling one hour prior to the remaining rafts resulting in the completion of two electrofishing passes per trip.

Native rare fishes collected were immediately placed in a live well or five-gallon bucket separate from nonnative fishes. Rare native fishes were measured (nearest 1 mm), weighed (nearest 5 g) and checked for the presence of a Passive Implant Transponder (PIT) tag. If a PIT tag was detected, the number was recorded and it was noted that the fish was a recaptured fish. If the presence of a PIT tag was not detected and the fish was ≥ 150 mm TL, a 134.2 kHz PIT tag was implanted and the capture status was recorded as a new capture (Davis 2010).

A mark and recapture study from Shiprock Bridge to Mexican Hat for channel catfish was initiated in 2011. The purpose of this effort was to determine exploitation rates and generate population estimates. All channel catfish and common carp ≥ 200 mm TL were tagged with individually numbered anchor tags and released back to the river. A population estimate was calculated for adult and juvenile channel catfish, and adult common carp using a Lincoln-Petersen estimate with Chapman's Correction. The estimate was based on fish recaptured during the first trip conducted after tagging. Fish that moved upstream of Shiprock Bridge were not included in the calculation of exploitation rates or the population estimate. Exploitation rates, *u*, were estimated as the proportion of recaptured marked fish to marked fish (Deroba et al. 2005),

$$u = R/M$$

where, R represents number of recaptured fish and M represents number of marked fish.

To assess long-term trends in distribution and abundance, mean catch rates (fish per hour of electrofishing CPUE) and standard error (± 1 SE) were calculated using the software package SPSS version 13.0 (2004). Species CPUE were calculated as the total number of fish collected divided by the total sampling effort (hours of electrofishing). If CPUE data met the assumptions of normality and equality of variance, a one-way analysis of variance (ANOVA) was conducted to determine if significant differences existed. Multiple pairwise comparisons using Bonferroni post-hoc tests were used to determine where significant differences existed. If data were heteroscedastic, and transformations were unsuccessful in attaining equal variance, an ANOVA on ranked data (Kruskal-Wallis) was conducted with Nemenyi post-hoc tests to determine where significant differences existed (Zar 1996). Significance levels were set at $P<0.05$.

Data for each removal section were summarized by trip. Catch rates among individual trips were analyzed to assess temporal changes within the year. Due to difference in the number and timing of removal trips conducted in each section among years, we used data collected during the annual sub-adult and adult fall monitoring to assess long term trends in catch rates. These data were collected under standardized monitoring protocols with the primary assumptions that sampling methods employed were appropriate to the species, size, and habitats being sampled, and that sampling efficiency remained relatively constant (SJRIP 2012). Catch data pre and post intensive removal were analyzed to assess the effects of removal on nonnative fishes.

RESULTS

PNM WEIR TO HOGBACK DIVERSION (RM 166.6 – 159.0)

A total of 42 channel catfish and 19 common carp were removed from this section during two trips (July and November) and 31.3 hours of electrofishing (Appendix A-1). Additional nonnative fishes removed from the section included brown trout *Salmo trutta*, bullhead catfishes *Ameiurus spp.,* and green sunfish *Lepomis cyanellus*.

CHANNEL CATFISH

In 2013, mean channel catfish CPUE for all life stages combined was 1.2 fish/hour. Catch rates were similar between trips and were 1.9 fish/hour in July and 0.5 fish/hour in November. No juvenile channel catfish were collected during the two trips in 2013. Fewer total fish (N = 42) were removed in this section in 2013, compared to 2012 (N = 301). Out of the 42 fish removed in 2013, 33(78.6%) came from the July trip.

Trends in juvenile channel catfish CPUE , generated using fall monitoring data, have declined since nonnative removal was initiated in this section in 2001 (Figure 2). Juvenile channel catfish were collected during all years prior to the initiation of intensive removal and 2013 marked the fifth consecutive year, post–removal, that no juvenile channel catfish were collected. In 2013, adult channel catfish catch rates were significantly lower than in all years prior to the start of intensive removal.

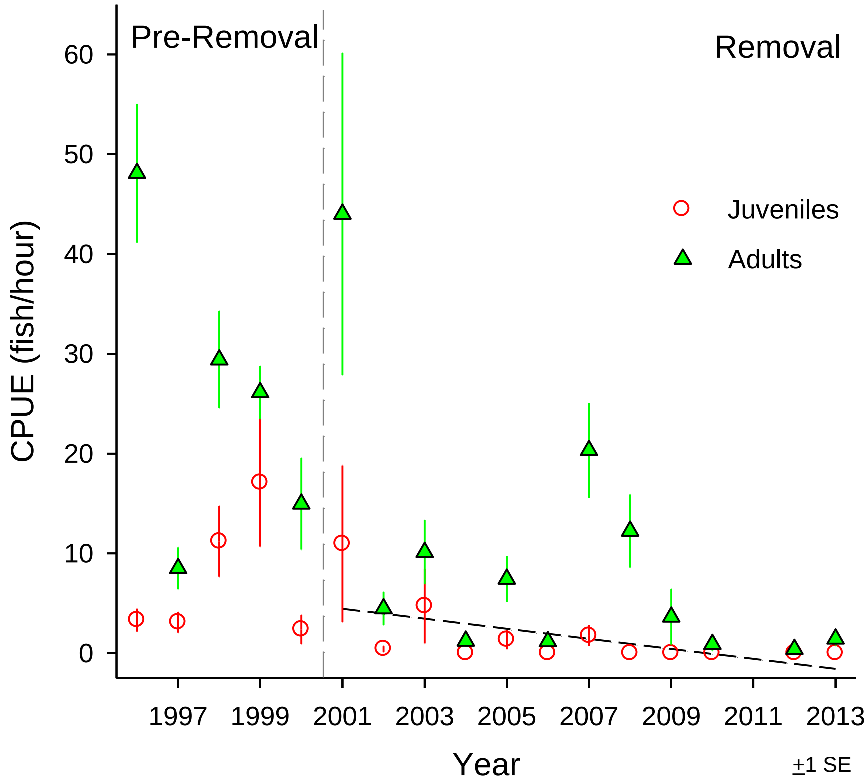

Figure 2. Channel catfish CPUE (fish/hour) during annual fall monitoring by year, PNM Weir to Hogback Diversion; 1996-2013. Adult CPUE is represented by triangles and juvenile CPUE is represented by circles. A line was fitted if the trend was significant ($y= 4.937 – 0.638x$; $r^2 = 0.39$; $p = 0.04$). The vertical hash line represents the initiation of intensive nonnative removal in this section. Error bars represent ± 1 SE.

Mean total length of channel catfish in 2013 was 399 mm TL (range 305 to 560 mm TL) (Figure 3). The majority of channel catfish collected in 2013 was composed of newly recruited adults (300-400 mm TL).The percentage (4.8%) of large adult channel catfish, >500 mm TL, was reduced from 18.8% in 2012.

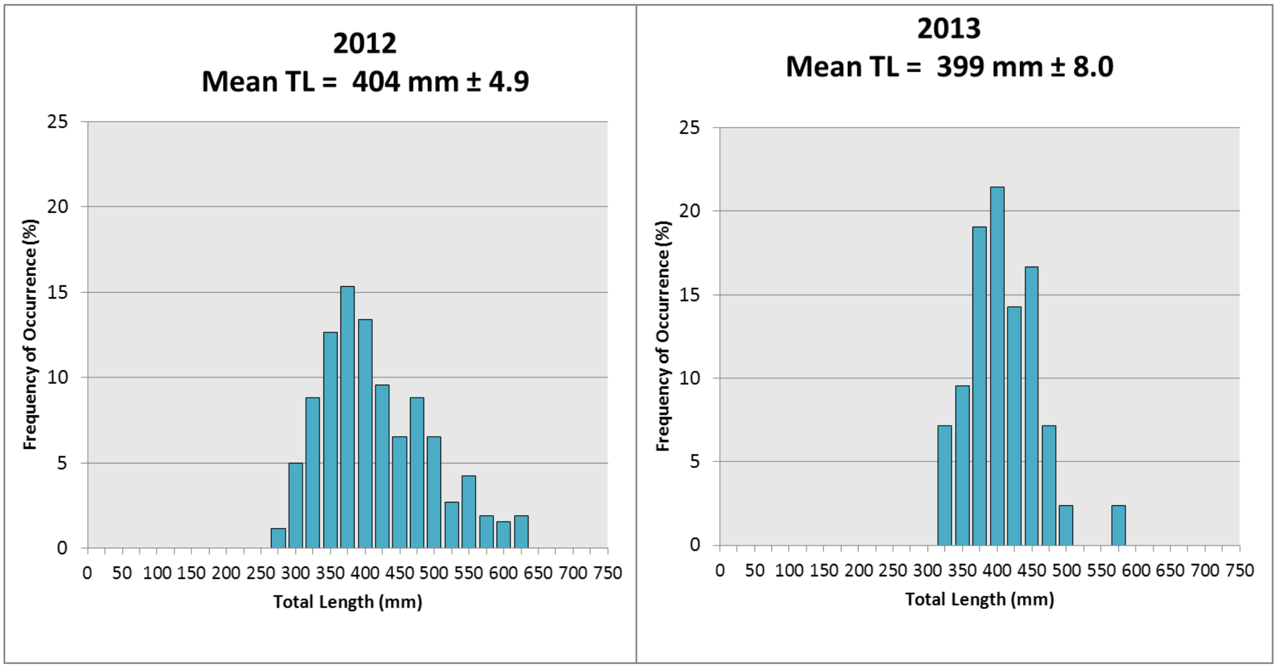

Figure 3. Mean TL (1 SE) and length frequency histograms for channel catfish collected from PNM Weir to Hogback Diversion; 2012 -2013. The y-axis represents percentage (%) of catch and the x-axis represents total length.

COMMON CARP

Common carp CPUE varied little between the two trips conducted in 2013. Catch rates were ≤ 1.0 fish/hour during each trip and ranged from 0.3 fish/hour in July to 0.8 fish/hour in November. Mean common carp CPUE, all life stages combined, in 2013 was 0.5 fish/hour.

Trends in common carp CPUE, generated using fall monitoring data, have declined since nonnative removal was initiated in 2001 (Figure 4). Common carp mean CPUE was < 1.0 fish/hour from 2008-2012. No common carp were collected in this section during fall monitoring in 2013.

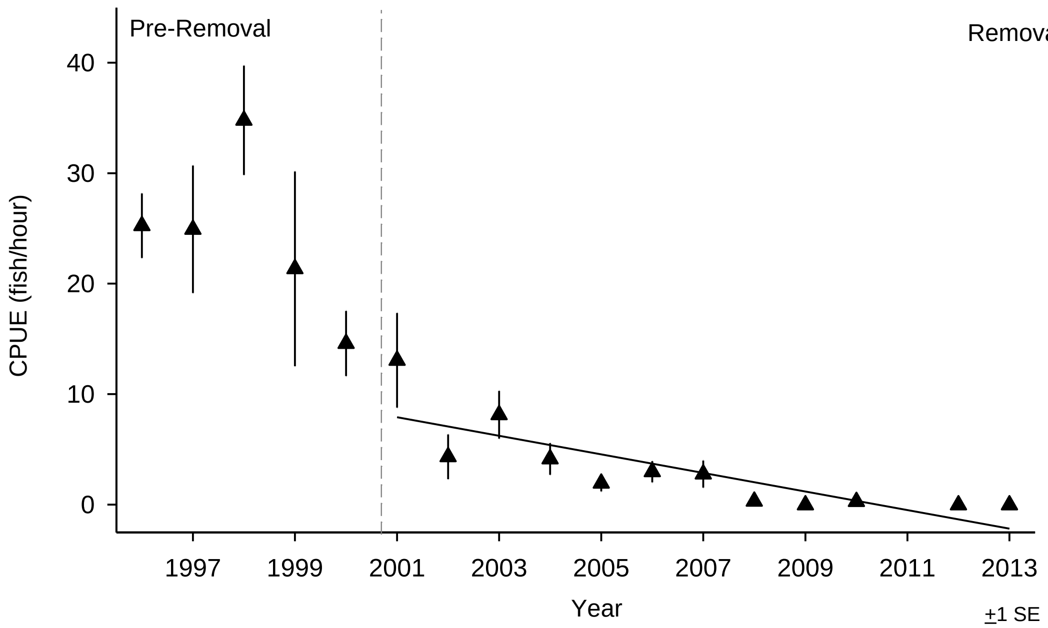

Figure 4. Common carp CPUE (fish/hour) during annual fall monitoring by year, PNM Weir to Hogback Diversion; 1996-2013. A line was fitted to the data if the trend was significant (y= 8.601 – 1.027x; r^2= 0.71; p= 0.001). The vertical hash line represents the initiation of intensive nonnative removal in this section. Error bars represent ± 1 SE.

HOGBACK DIVERSION TO SHIPROCK BRIDGE (RM 158.8 – 147.9)

A total of 1,057 channel catfish and 58 common carp were removed during three trips (March, July and August) and 76.3 hours of electrofishing (Appendix A-2). In addition to channel catfish and common carp, other nonnative fishes collected included rainbow trout *Oncorhynchus mykiss*, brown trout, bullhead catfishes, largemouth bass *Micropterus salmoides*, and green sunfish.

CHANNEL CATFISH

Channel catfish CPUE in 2013 ranged from 5.7 fish/hour to 24.6 fish/hour (Figure 5). Catch rates observed in July were significantly higher than all other trips (ANOVA; $F_{(2, 85)}$ = 55.435; p <0.05). The mean channel catfish CPUE in 2013, all life stages combined, was 14.2 fish/hour. Of the 1,057 channel catfish removed, only 4.8 % (N= 51) were juveniles, whereas in 2012, juveniles comprised 33.6% percent of the 1,000 channel catfish removed.

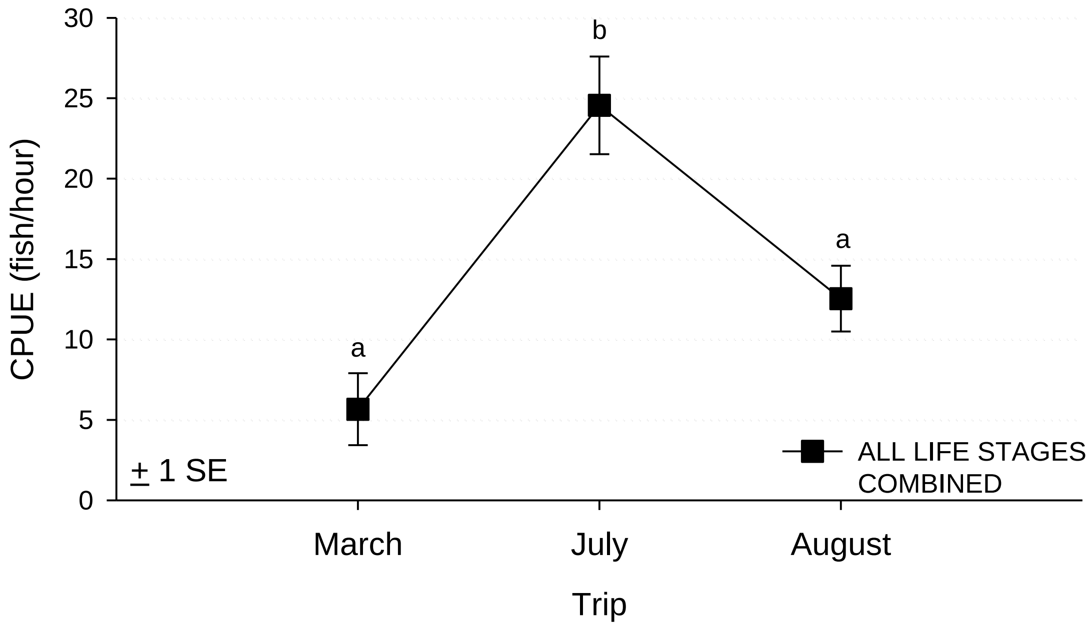

Figure 5. Channel catfish CPUE (fish/hour) by trip within the Hogback Diversion to Shiprock Bridge Section; 2013. Error bars represent ± 1 SE. Letters represent comparisons among trips (Nemenyi post-hoc). Similar letters represent that significant differences did not exist and unlike letters indicate that significant differences were detected among comparisons.

During fall monitoring in 2013, juvenile channel catfish CPUE was 0.7 fish/hour, compared to 8.5 fish/hour in 2012. Adult catch rates were 18.1 fish/hour and similar to values observed in 2012 (Figure 6).

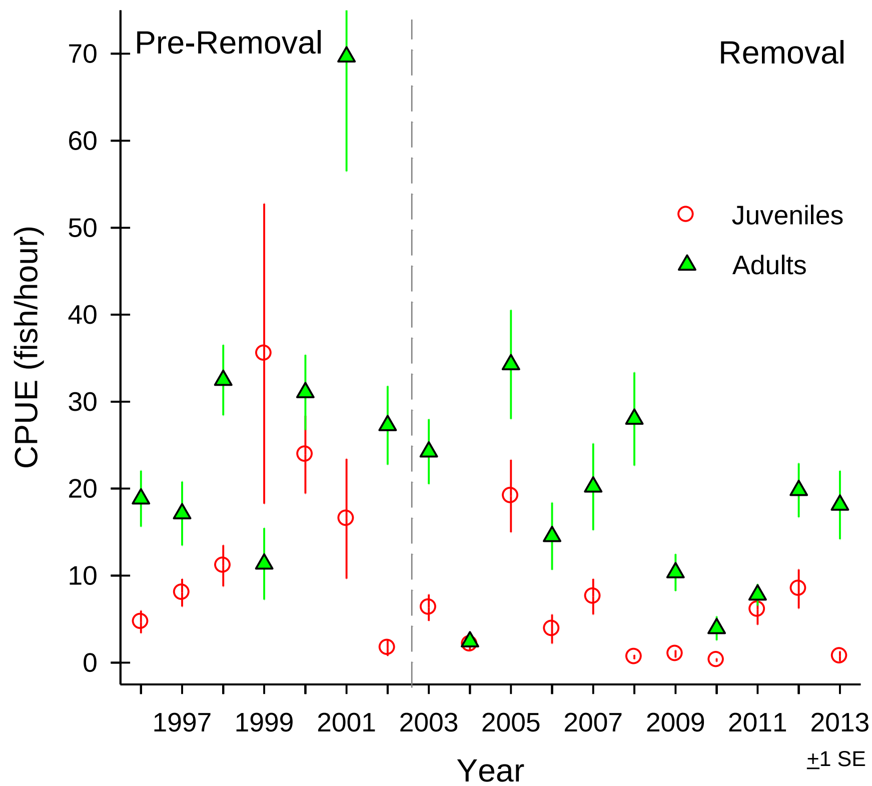

Figure 6. Channel catfish CPUE (fish/hour) during annual fall monitoring by year, Hogback Diversion to Shiprock Bridge; 1996-2013. Adult CPUE is represented by triangles; juvenile CPUE is represented by circles. The vertical hash line represents the initiation of intensive nonnative removal in this section. Error bars represent ± 1 SE.

Mean total length of channel catfish in 2013 was 370 mm (range 240 to 690 mm) (Figure 7). The length frequency distribution of channel catfish in 2013 shifted compared to patterns observed in 2012. In 2013, newly recruited adults (300-400mm TL) comprised the majority of the catch and represented 77% of the catch. There was a reduction in the frequency of occurrence in larger channel catfish >500 mm TL in 2013 compared to 2012, 6.3% and 18.8% respectively.

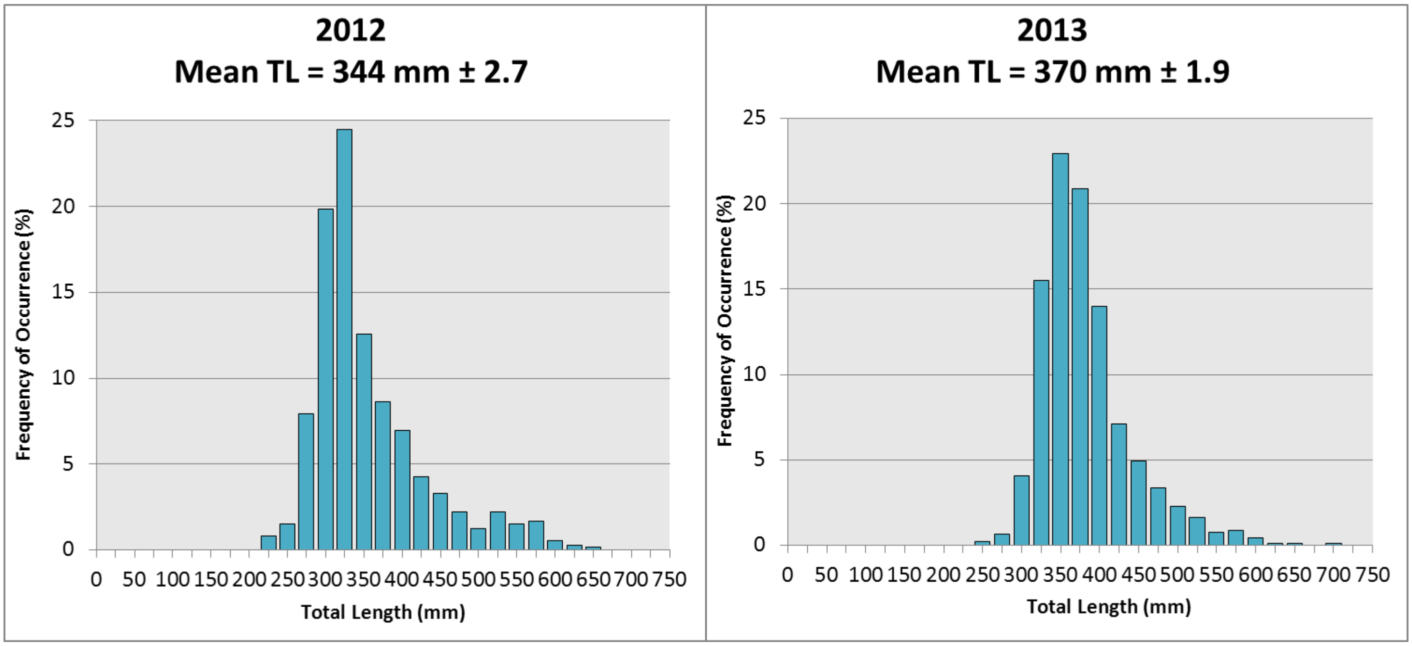

Figure 7. Mean TL (1 SE) and length frequency histograms for channel catfish collected from Hogback Diversion to Shiprock Bridge; 2012 - 2013. The y-axis represents percentage (%) of catch and the x-axis represents total length.

COMMON CARP

Common carp catch rates varied little among the three trips in 2013. Mean common carp CPUE, all life stages combined, in 2013 was 0.8 fish/hour (Figure 8).

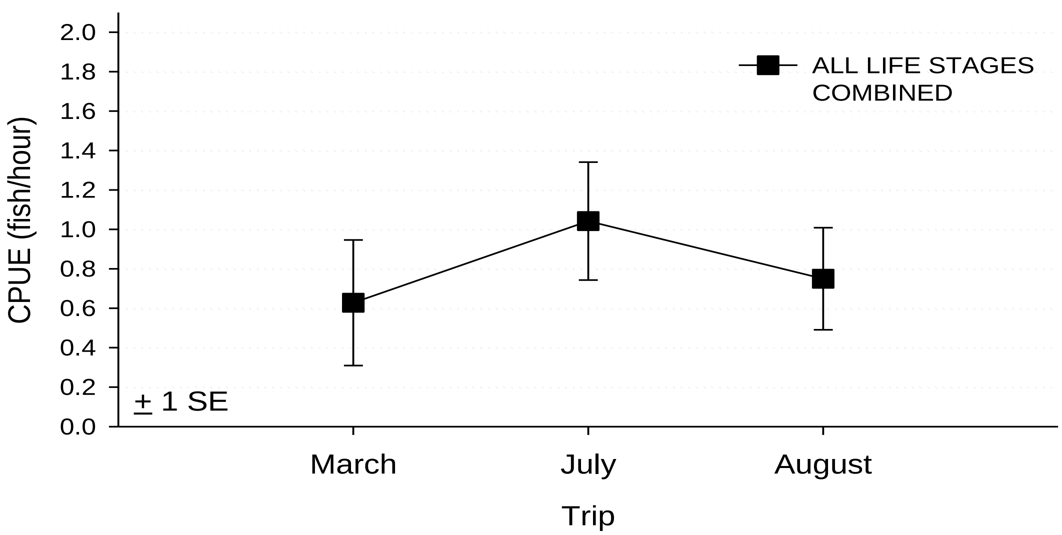

Figure 8. Common carp CPUE (fish/hour) by trip within the Hogback Diversion to Shiprock Bridge section; 2013. Error bars represent ± 1 SE.

Common carp CPUE, using fall monitoring data, has declined since nonnative removal was initiated in 2003 (Figure 9). No adult common carp were collected during fall monitoring from Hogback Diversion to Shiprock Bridge in 2013. Catch rates for juvenile common carp were 0.7 fish/hour.

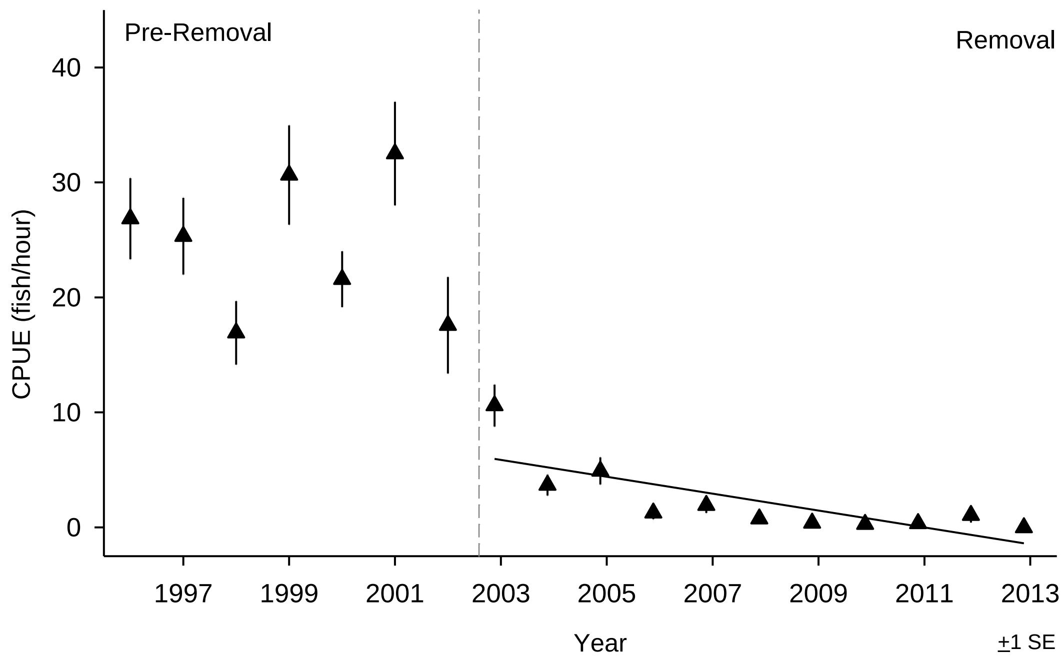

Figure 9. Common carp CPUE (fish/hour) during annual fall monitoring by year, Hogback Diversion to Shiprock Bridge; 1996-2013. A line was fitted to the data if the trend was significant ($y=6.241 - 0.825x$; $r^2= 0.60$; $p= 0.009$). The vertical hash line represents the initiation of intensive nonnative removal in this section. Error bars represent ± 1 SE.

SHIPROCK BRIDGE TO MEXICAN HAT (RM 147.9 - 52.9)

One tagging trip and three removal trips (April/May, June, and September) were conducted from Shiprock Bridge to Mexican Hat in 2013. During removal trips, a total of 11,073 channel catfish and 81 common carp were removed in 482 hours of electrofishing. Nonnative fish removal also took place in conjunction with FWS Colorado River Fishery Project's annual fall monitoring in September, resulting in the removal of an additional 1,740 channel catfish and 44 common carp in 103.9 hours of electrofishing. For the year, a total of 12,813 channel catfish and 125 common carp were removed during 586 hours of electrofishing (Appendix A-3). Other nonnative fishes removed included brown trout, bullhead catfishes, green sunfish, and largemouth bass. No striped bass or walleye were collected or observed. In 2013, eight roundtail chub *Gila robusta* were collected.

MARK AND RECAPTURE

A total of 1,333 channel catfish and 17 common carp were collected and implanted with individual alphanumeric anchor tags during a trip from Shiprock Bridge to Mexican Hat, UT. Total length was taken from all tagged fish to determine exploitation rates by size class. Adult channel catfish, ≥ 300mm TL, comprised 63% of the total number of channel catfish tagged (N=843), while juvenile channel catfish comprised 37% (N=490). In addition to nonnative fishes, we captured 50 Colorado pikeminnow and 91 razorback sucker during the tagging trip.

Exploitation rates for channel catfish were generated for each size class for the first removal trip post tagging (Table 1). The exploitation rate for all size classes was 7%. Exploitation rates ranged from 1.6 % for juvenile channel catfish to 23.6 % for fish 500-599 mm TL.

Table 1. Channel catfish exploitation rates from Shiprock Bridge to Mexican Hat, UT, 2013. Numbers in parentheses in the Mark Pass row represent total number of channel catfish tagged in that size class. Numbers in parentheses in the Trip 1 row represent total number of channel catfish recaptured for that size class and trip and percentage is the exploitation rate for that size class during that trip.

	Total Length (mm) of Channel Catfish at Time of Tagging					
	200-299 mm TL	300-399 mm TL	400-499 mm TL	500-599 mm TL	600+ mm TL	Total
Mark Pass	37%	41%	16%	5%	1%	100%
	(490)	(545)	(212)	(72)	(14)	(1,333)
Trip 1 April/May	1.6%	8.3%	9.4%	23.6%	21.4%	7.0%
	(8)	(45)	(20)	(17)	(3)	(93)

During the tagging trip, 843 adult, ≥ 300 mm TL, channel catfish were tagged. On the first removal trip in April/May, 2,070 adult fish were captured including 85 anchor-tagged fish. The Lincoln-Petersen population estimate for adult channel catfish from Shiprock Bridge to Mexican Hat, UT was 20,324 (95% CI = 16,057-24,590; CV=10.5%, SE=2,133).

A total of 490 juvenile channel catfish (200-299mm TL) were tagged in 2013. During the post tagging removal trip, a total of 855 juvenile fish were captured including 8 anchor-tagged fish. The Lincoln-Petersen population estimate for juvenile channel catfish from Shiprock Bridge to Mexican Hat, UT was 46,699 (95% CI = 17,319-76,078; CV=31.46%, SE=14,690).

A Lincoln-Petersen population estimate was completed for adult common carp in 2013. During the tagging trip, 17 adult common carp were tagged. Twenty-seven adult carp were collected during the first removal trip including four tagged fish. The Lincoln-Petersen population estimate for adult common carp from Shiprock Bridge to Mexican Hat, UT was 100 (95% CI = 26-174; CV=37%, SE=36.9).

Using the population estimates, we estimated the percentage of the estimated population removed by trip and for the year. This estimate does not take in to account fish mortality and recruitment, or immigration and emigration. If these estimates are accurate, we potentially removed 35% of the adult channel catfish population estimate (Table 2) and 8% of the juvenile population estimate (Table 3) from Shiprock Bridge to Mexican Hat, Utah in 2013. A similar estimate of percentage of fish removed in 2011 for adult channel catfish shows that the pre-exploitation estimate for 2012 did not surpass the pre-exploitation estimate for 2011 (Figure 10). The pre-exploitation estimate for adult channel catfish in 2013 was higher than these estimates in 2011 and 2012. This may be the result of large numbers of juvenile channel catfish recruiting to the newly-recruited adult size class.

Table 2. Number of adult channel catfish removed during each trip. The percentage (%) of population estimate removed each trip is based on the population estimate for adult channel catfish from Shiprock Bridge to Mexican Hat. The estimated number of fish remaining is determined from the population estimate.

Trip	Adults Removed	% of Pop Estimate	Estimated # of Fish Remaining
April	2,070	10.2	18,254
June	2,386	13.1	15,868
September	518	3.3	15,350
Fall monitoring	317	2.1	15,033
Total	**5,291**	**26.0**	**15,033**

Table 3. Number of juvenile channel catfish removed during each trip. The percentage (%) of population estimate removed each trip is based on the population estimate for juvenile channel catfish from Shiprock Bridge to Mexican Hat. The estimated number of fish remaining is determined from the population estimate.

Trip	Juveniles Removed	% of Pop Estimate	Estimated # of Fish Remaining
April	855	1.8	45,844
June	2,407	5.3	43,437
September	313	0.7	43,124
Fall monitoring	162	0.4	42,962
Total	**3,737**	**8.0**	**42,962**

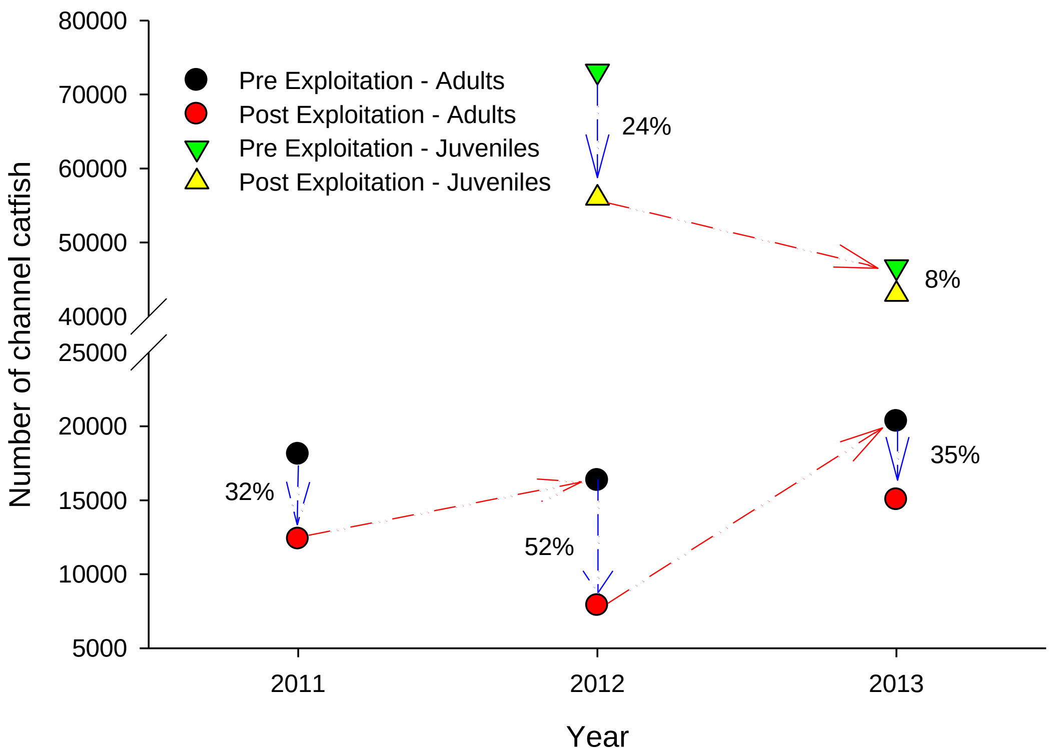

Figure 10. Pre and post exploitation estimates for adult and juvenile channel catfish, Shiprock Bridge to Mexican Hat, Utah: 2011-2013. Percentages represent the reduction between population estimates and the estimated number of fish remaining after the four removal trips.

REMOVAL TRIPS

CHANNEL CATFISH

Channel catfish CPUE, all life stages combined, varied among trips in 2013 (Figure 11). Juvenile channel catfish CPUE ranged from 4.1 to 24.6 fish/hour, with the highest catch rates occurring in June. Adult channel catfish CPUE ranged from 3.1 to 13.5 fish/hour of electrofishing. The April/May and June trips had the highest catch rates for adult channel catfish. Mean CPUE, all life stages, in 2013 was 19.2 fish/hour, compared to 62.9 fish/hour in 2012.

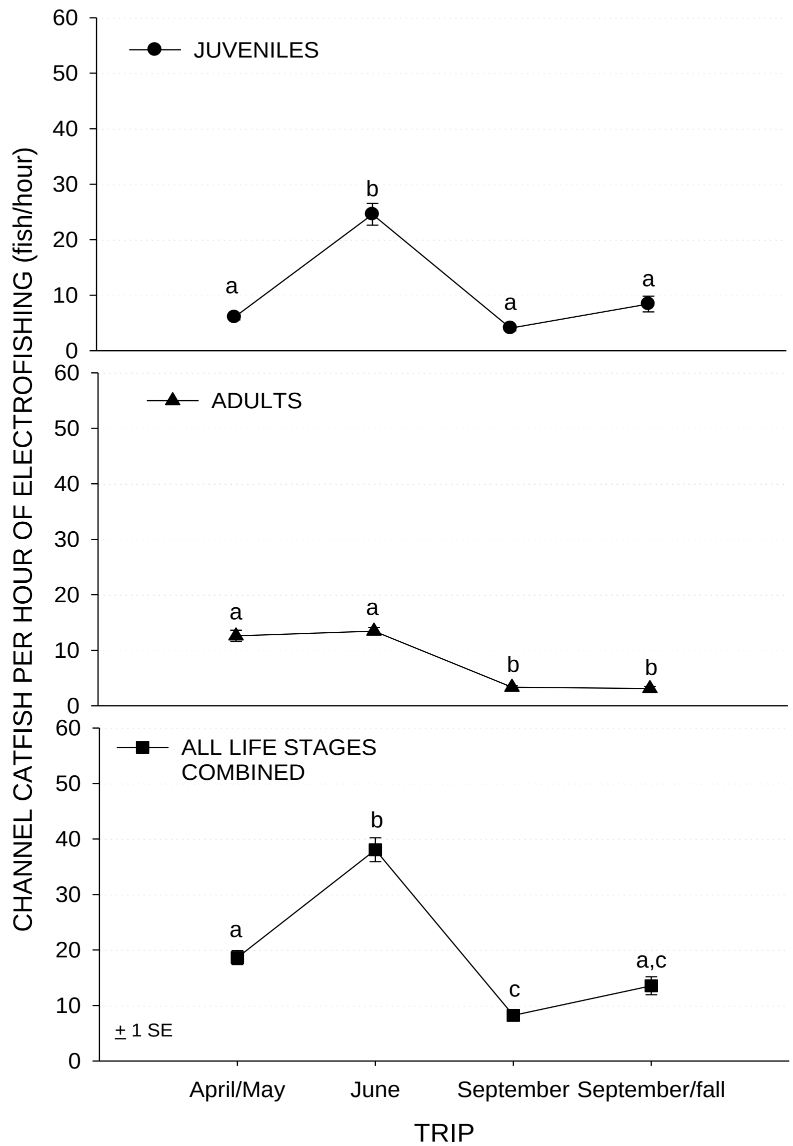

Figure 11. Channel catfish CPUE (fish/hour) by trip from Shiprock Bridge to Mexican Hat; 2013. Error bars represent ± 1 SE. Letters represent comparisons among trips (Nemenyi post-hoc). Trips with the same letter did not differ from each other.

Before intensive removal began in 2006, juvenile channel catfish catch rates generated from fall monitoring data were fairly consistent among years (Figure 12). After removal efforts began, juvenile catch rate trends exhibited a general increase over time until 2013. The juvenile channel catfish CPUE in 2013 was 5.9 fish/hour, compared to 59.8 fish/hour in 2012. Adult CPUE in 2013 was 2.9 fish/hour and 20.9 fish/hour in 2012. Both juvenile and adult CPUE in 2013 were the lowest observed catch rates in this section from 1996-2013.

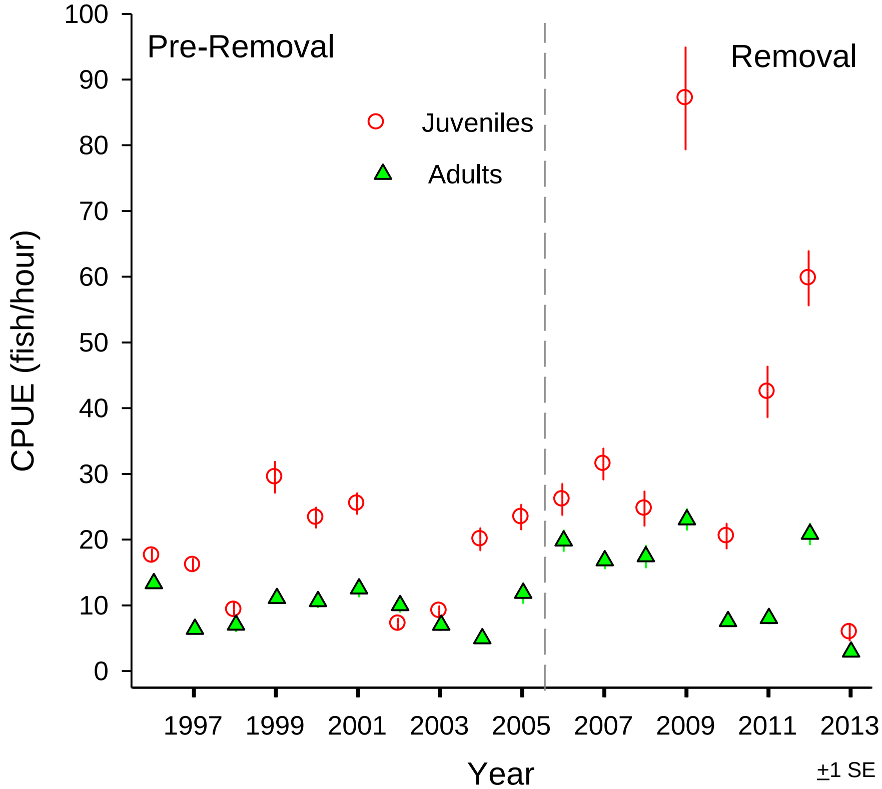

Figure 12. Channel catfish CPUE (fish/hour) during annual fall monitoring by year, Shiprock Bridge to Mexican Hat; 1996-2013. Adult CPUE is represented by triangles. Juvenile CPUE is represented by circles. The vertical hash line represents the initiation of intensive nonnative removal in this section. Error bars represent ± 1 SE.

Mean total length of channel catfish in 2013 was 293 mm (range 40 to 702 mm)(Figure 13). The majority of measured channel catfish (44.3 %) were between 300 – 400 mm TL, 39.3 % were < 300 mm TL, and 16.4 % were > 400 mm TL.

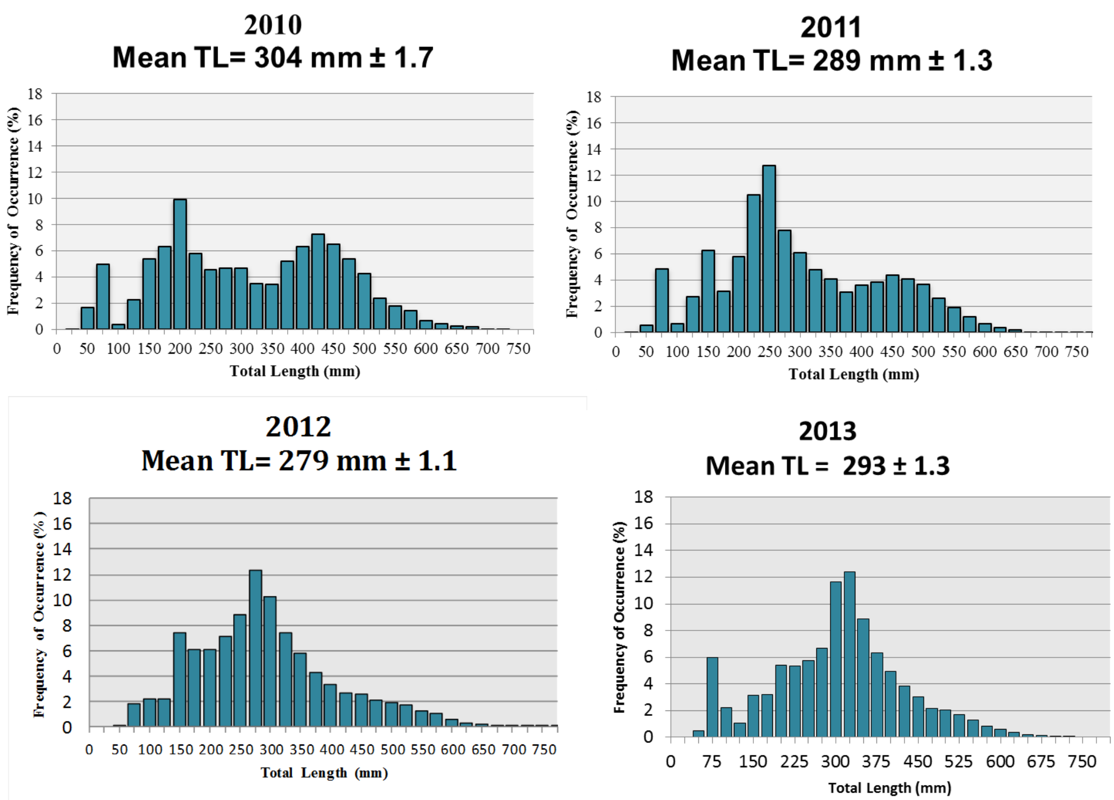

Figure 13. Mean TL (1 SE) and length frequency histograms by trip for channel catfish collected from Shiprock Bridge to Mexican Hat Utah; 2010-2013. The y-axis represents percentage (%) of catch and the x-axis represents total length

COMMON CARP

Catch rates for common carp were < 0.25 fish/hour during the first three removal trips conducted in 2013 (Figure 14). Mean common carp CPUE in 2013 was 0.25 fish/hour.

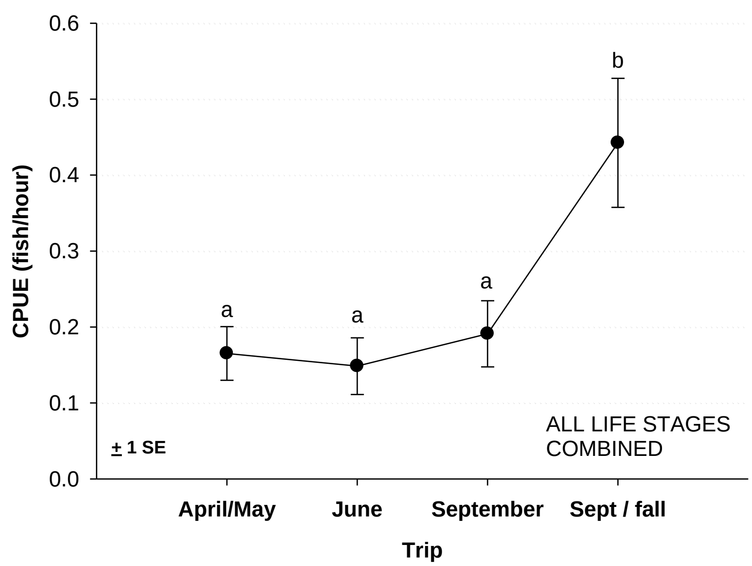

Figure 14. Common carp CPUE (fish/hour of electrofishing) during 2013 nonnative removal trips from Shiprock Bridge to Mexican Hat. Error bars represent ± 1 SE. Letters represent comparisons among trips (Nemenyi post-hoc). Trips with the same letter did not differ from each other

A comparison of common carp catch rates among years of adult fall monitoring shows a decline in CPUE during pre-removal efforts and a continuing decling trend after intensive removal began in 2006 (Figure 15). Catch rates have remained < 1.0 fish/hour for the last five years. Mean catch rates in 2013 were 0.49 fish/hour.

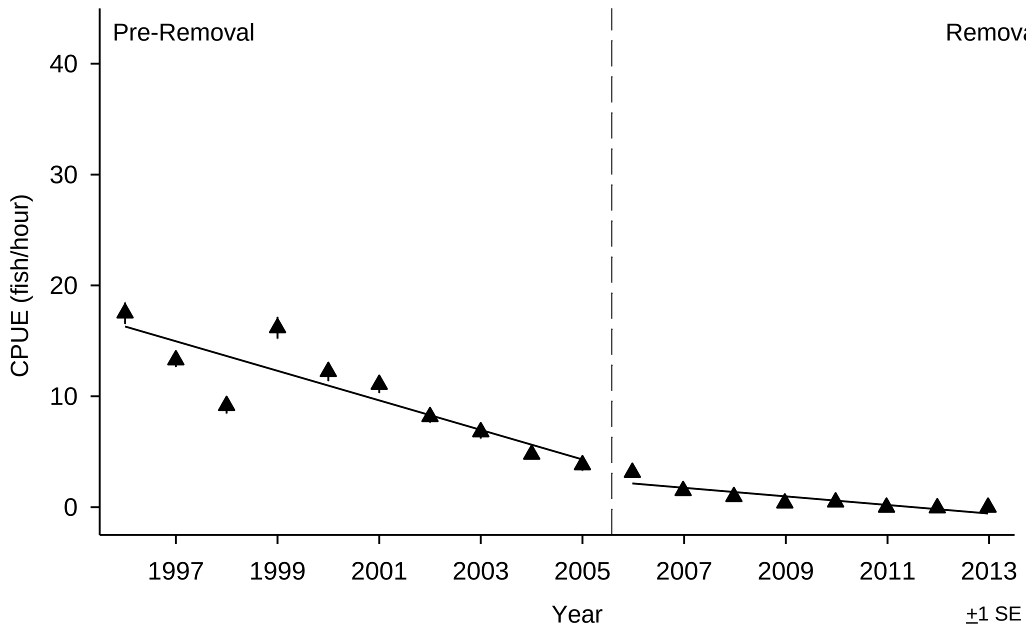

Figure 15. Common carp CPUE (fish/hour) during annual fall monitoring by year, Shiprock Bridge to Mexican Hat; 1996-2013. A line was fitted to the data if the trend was significant (96-05: y= 16.289 – 1.332x; r^2 = 0.77; p<0.001; 06-12: y= 2.484 – 0.467; r^2= 0.81; p=0.01). The vertical hash line represents the initiation of intensive nonnative removal in this section. Error bars represent ± 1 SE.

RARE FISH COLLECTIONS

A total of 573 Colorado pikeminnow and 2,041 razorback sucker were captured during nonnative removal trips from PNM Weir to Mexican Hat, Utah (Appendix A-3). Sixty- one Colorado pikeminnow and 676 razorback sucker were collected from PNM Weir to Hogback Diversion; 98 Colorado pikeminnow and 897 razorback sucker were collected from Hogback Diversion to Shiprock Bridge; and 364 Colorado pikeminnow and 378 razorback sucker were collected from Shiprock Bridge to Mexican Hat. These totals do not include rare fishes collected during annual sub-adult and adult fish community monitoring conducted by U.S Fish and Wildlife Service- Colorado Fishery Project but do include the rare fish collected during the tagging trip in early April from Shiprock Bridge to Mexican Hat. For analysis purposes, fish that were recaptured multiple times on an individual trip or throughout the year were included, but recaptures of an individual fish on the same day were excluded.

COLORADO PIKEMINNOW

All Colorado pikeminnow collected in 2013 were considered to be stocked fish. A total of 80 individual fish had PIT tags at time of capture. Recaptures of PIT tagged fish ranged from 1- 3,355 days since first encounter. Fish were classified as first encounters when the fish was stocked in the river or collected and tagged in the river. Days since first encounter could not be calculated for all PIT tagged Colorado pikeminnow due to errors when recording PIT tag numbers. The majority of PIT tagged fish (76.5%, n= 65) were captured < 730 days since first encounter and 20 fish were recaptured > 730 days since first encounter. Various age classes were collected dating back to 2002; however, the 2011 year class comprised the majority of recaptures (Table 4).

Table 4. Summary of Colorado pikeminnow, by known year class, collected during nonnative fish removal in 2013.

Year class	N
2002	1
2004	1
2005	1
2007	2
2008	3
2009	4
2010	23
2011	36
2012	3

A total of 361 Colorado pikeminnow were implanted with a PIT tag at the time of capture. These newly implanted fish ranged in size from 151 – 531 mm TL, with a mean TL of 236 mm. One-hundred-thirteen captures were not implanted with a PIT tag because they were < 150 mm TL. Mean TL of Colorado pikeminnow collected during our efforts in 2013 was 228 mm TL (range = 65 – 710 mm TL) (Figure 16). Fish < 150 mm TL comprised 19.6 % (n = 107) of the total catch and fish > 400 mm TL comprised 4.9 % (n = 27) of the catch. Nineteen adult Colorado pikeminnow were collected including four fish ranging from 450 – 500 mm TL and 15 individuals > 500 mm TL.

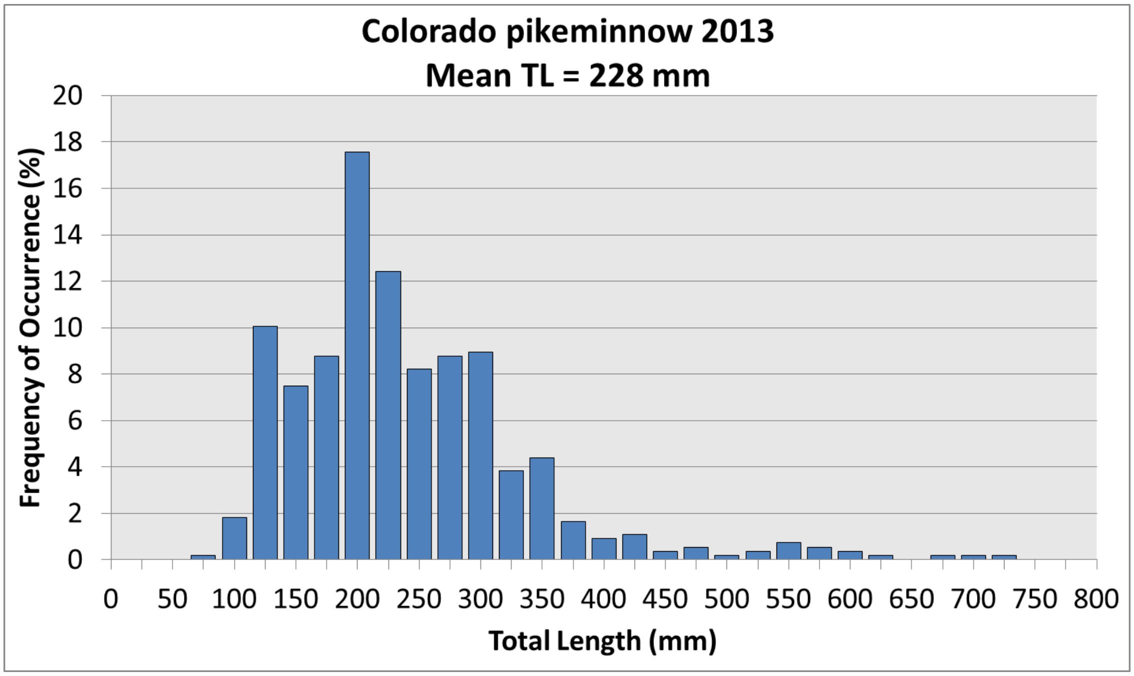

Figure 16. Mean TL (1 SE) and length frequency histogram for Colorado pikeminnow collected during intensive nonnative fish removal trips; 2013. The y-axis represents percentage (%) of catch and the x-axis represents total length.

On June 21, 2012, a possible spawning aggregation of adult Colorado pikeminnow was found at RM 120. The netter on the raft was able to net six adult fish and observed more adults that went uncaptured. The six fish captured were all tuberculated males ranging from 450- 546 mm TL. On the opposite side shoreline the other shocking raft also picked up a small aggregation of three Colorado pikeminnow at the same time. One of these fish was a 660 mm TL tuberculated male and the other two were 434 and 452 mm TL. On June 22, 2013, another possible spawning aggregation of Colorado pikeminnow was found at RM 119. Five adult Colorado pikeminnow were collected by one raft. The fish ranged from 531- 660 mm TL and included three tuberculated ripe males. A 710 mm TL fish was collected just upstream from RM 118 the day before and a 695 mm TL fish was collected downstream of RM 118 on June 22. Both these fish were tuberculated ripe males. Out of the 16 fish collected in the combined two years, only one individual adult Colorado pikeminnow was collected in both these aggregations in 2012 and 2013.

RAZORBACK SUCKER

All razorback sucker collected in 2013 were considered to be stocked fish. Although 108 razorback sucker were lacking PIT tags at time of capture, we assumed these fish were stocked fish. The majority of razorback sucker implanted with a PIT tag in 2013 had scales collected for the study using elemental analysis to determine razorback sucker natal origin. All 108 of these fish were implanted with a 134.2 kHz PIT tag and subsequently released. Various known age classes of razorback sucker were recaptured dating back to 1992 with the majority (69%) of recaptures composed of the 2008-2009 year class (Table 5).

Table 5. Summary of razorback sucker by age class collected during nonnative fish removal in 2013.

Year class	N
1992	1
1999	6
2000	8
2001	22
2002	8
2003	9
2004	3
2005	1
2006	25
2007	107
2008	636
2009	351
2010	231

Days in river since first encounter ranged from 1 – 6,479 days. Of the 1,577 razorback sucker that had a known stocking history, 52.7% (n=519) were recaptured < 1 year since first encounter and 5.5% (n=116) were recaptured > 5 years since first encounter. Fourteen individuals were recaptured 10 years since first encounter. One fish stocked in the San Juan River in 1995 was recaptured in 2013. This was the 6th recapture of this fish in 17.8 years.

Mean razorback sucker TL in 2013 was 432 mm and sizes ranged from 274 – 575 mm TL (Figure 17). Of the 1,732 measured fish, 76.4% (n = 1,324) were considered to be adult fish (> 400mm TL). Of these adult fish, 186 fish were >500mm TL.

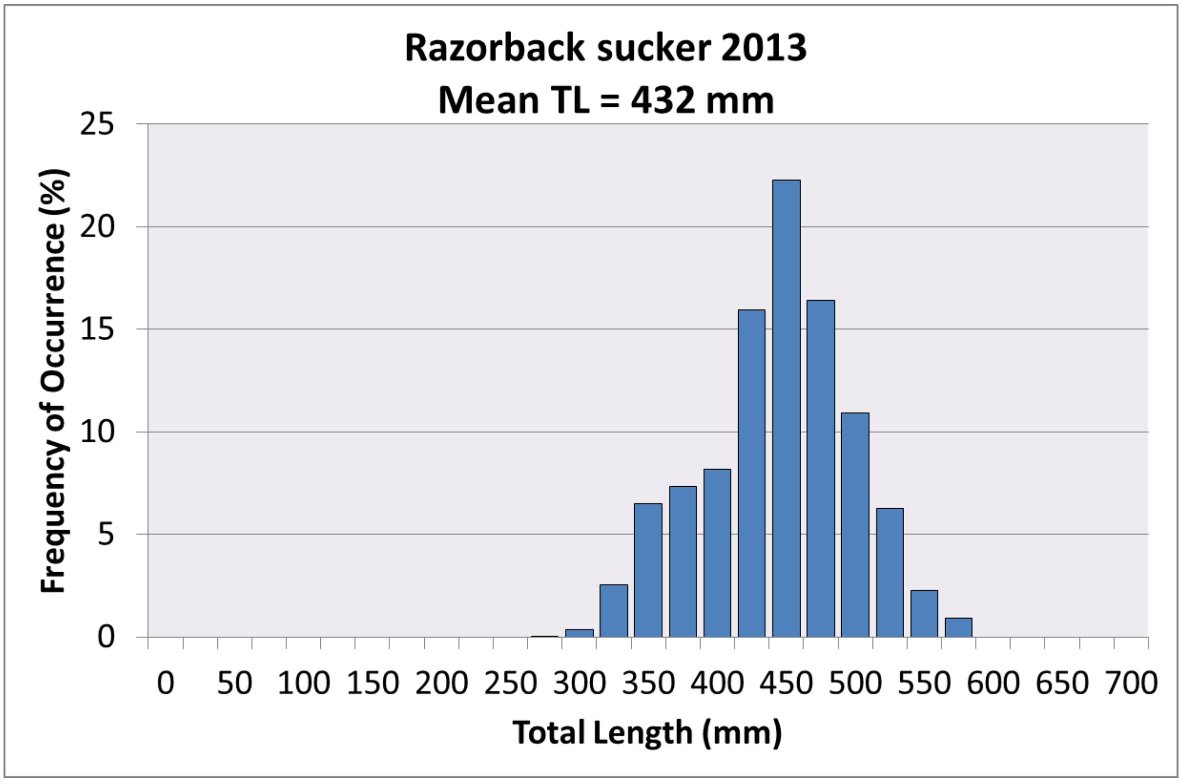

Figure 17. Mean TL (1 SE) and length frequency histogram for razorback sucker collected during intensive nonnative fish removal trips; 2013. The y-axis represents percentage (%) of catch and the x-axis represents total length.

DISCUSSION

Intensive nonnative removal completed its 13th consecutive year from PNM Weir to Hogback Diversion in 2013. Typically the two removal trips in this section are completed in July and August. Summer monsoon rains in August caused spikes in flow and increased turbidity resulting in less than favorable sampling conditions. We postponed the August trip until better sampling conditions were present. The trip was rescheduled and completed in November. The number of fish removed in 2013 was greatly reduced compared to 2012 and was likely a result of the low numbers of channel catfish removed during the November trip. Lower catch rates in November could be a result of seasonal movement of channel catfish. Data from previous years suggest that channel catfish move upstream in the summer months. Since 2011, channel catfish are tagged downstream of Shiprock Bridge by NMFWCO and downstream of Mexican Hat, Utah by UDWR and every year tagged channel catfish are recaptured 8-140 miles upstream in this section. The selective fish ladder at PNM Weir normally experiences an increase in channel catfish using the fish passage in late July and August, supporting the idea that upstream movement of channel catfish occurs. However, the fish ladder was inoperative due to high sediment and debris jams caused by the high flow and rainstorm events in August and there were not increases in numbers of channel catfish using the passage in July.

Prior to the initiation of removal in 2001, channel catfish catch rates in this section from PNM Weir to Hogback Diversion, during fall monitoring, varied among years but suggested relatively high adult channel catfish abundance. Post initiation of intensive removal, catch rates for both juvenile and adult channel catfish still varied among years but both size classes have exhibited general declining trends. Juvenile channel catfish have not been collected in this section during fall monitoring for the last five years. The observed decline in juveniles is likely the cumulative result of intensive removal efforts in this section and adjacent downstream sections. Variation in CPUE data among years may be partially responsible for the failure to detect significant declining trends in adult channel catfish catch rates in this section during our study period. Although adult CPUE trends have not changed over time, catch rates in 2013 were significantly lower than values observed prior to removal.

In 2003, nonnative removal efforts were expanded to include the Hogback Diversion to Shiprock Bridge section. Catch rates for channel catfish have varied among years, but still remain relatively high. Juvenile catch rates during fall monitoring increased in 2011 and 2012, but declined to previous levels in 2013. The observed increases in 2011 and 2012 coincided with increases in juvenile abundance downstream of Shiprock Bridge. The high adult channel catfish catch rates in 2013 may be result of the 2011 and 2012 juvenile cohorts recruiting to the adult size class. The majority of channel catfish collected in this section in 2013 were composed of newly recruited adults. It is unknown if these fish recruited to the adult size class in this section or immigrated from downstream reaches. Recaptures of channel catfish that were tagged downstream of Shiprock Bridge and Mexican Hat, Utah illustrate widespread upstream movement and the potential to repopulate upstream removal reaches throughout the year. Although each removal section is analyzed and presented independently, it is important to recognize the effect that high juvenile channel catfish abundance in downstream areas may have on other removal sections because of immigration/emigration years later.

Beginning in 2008, the expansion of removal efforts to include two passes per trip from Shiprock Bridge to Mexican Hat, UT, was expected to result in significant declines in channel catfish abundance riverwide. Fall monitoring CPUE data showed that juvenile channel catfish catch rates continued to increase after the initiation of intensive removal in this section. Similar increases in juvenile channel catfish catch rates were observed after the initial years of intensive removal in the two uppermost sections of our study only to decline with continued exploitation (Davis and Duran 2009). Adult catch rates were stable the first four years of intensive removal and were reduced in 2010-2011 only to increase in 2012. Juvenile catch rates drastically declined during 2013 fall monitoring. Adult CPUE during fall monitoring also declined in 2013. Juvenile and adult CPUE in 2013 were the lowest observed catch rates for channel catfish from 1996-2013. These declines were also observed during the other three nonnative removal trips held throughout the year in this section. The overall total numbers of channel catfish removed in this section throughout the year were drastically reduced compared to previous years although there was a similar amount of effort. Total numbers of fish removed in 2013 were only 31% of the total amount removed in 2012. In 2012, the summer nonnative removal trip that typically took place in July was moved to June to try to target channel catfish during spawning. By collecting catfish as they aggregate to spawn or by collecting males that were guarding egg nests, we hope to disrupt spawning and lower reproductive success. While the success of this would be very difficult to quantify, it may be a reason we observed declines in juvenile channel catfish in 2013.

Equally important in the management of this species is a better understanding of our capture techniques and the associated efficiency of capturing various life stages of our target species. Previous analyses of our nonnative fish removal data by others suggest that our success in capturing channel catfish < 300mm TL may be limited (J. Morel unpublished data). A similar analysis of catch curves by 1-inch size groups suggests that channel catfish are fully recruited to our gear size once they attain a minimum length of 304-356mm TL (J. Davis unpublished data). Gerhardt and Hubert (1991) reported that in the Powder River drainage, the Ricker and Thompson-Bell model indicated that population structure and abundance of channel catfish would change considerably as exploitation rates (harvest) increased. They reported that an annual exploitation rate of 22% would result in a 75% reduction in overall abundance of fish ≥ 300 mm TL, and cause a substantial shift towards smaller individuals. Using the population estimate for juvenile channel catfish and the actual numbers we removed throughout the year from Shiprock Bridge to Mexican Hat, we estimated an 8% reduction between the population estimate and the estimated number of juvenile fish remaining after all the nonnative removal trips. It is also estimated that we removed 35% of the adult fish population estimate. Similar to 2012, our exploitation rates for adults were much higher than for juveniles. As juvenile fish in the river grow to sizes more susceptible to our gear type, we anticipate larger percentage reductions between pre-exploitation population estimates and the estimated number of fish remaining at the end of the year.

New methods and gear types for effectively capturing juvenile channel catfish are being considered for future efforts and include the use of electric seines, hoop nets and baiting areas prior to removal trips. By employing these new techniques it may be possible to focus our effort at removing size classes of channel catfish that we are currently ineffective in capturing and would likely result in an increase in our overall exploitation rates. Removing smaller sized fish, before reaching sexual maturity, may reduce overall reproductive potential and recruitment. Helms (1975) found that 1 of 10 channel catfish were sexually mature at 330 mm TL, compared to 5 of 10 at 380 mm TL. In addition, he found that channel catfish at 330 mm TL produced around 4,500 eggs/fish compared to the production of 41,500 eggs/fish at 380 mm TL.

Based on the length frequency histograms in all three removal sections, the majority of channel catfish captured in 2013 were newly recruited adult fish. A reduction in abundance of large channel catfish, 425-600 mm TL, may be important in not only limiting the reproductive potential of channel catfish in the San Juan River but may also limit overall predatory impacts on native fishes by channel catfish. Brooks et al. (2000) found that San Juan River channel catfish < 300 mm TL consumed almost exclusively macroinvertebrates and Russian olive fruits. Piscivory occurred most frequently in fish > 450 mm TL. Documentation of predation on endangered fishes during their study was not observed and was likely due to the relatively low number of endangered fishes in the San Juan River at the time of their study. An increase in smaller size classes of fish and a reliance on single year classes has been documented as a response to exploitation of channel catfish in the Mississippi River (Pitlo 1997). Maintaining or even increasing intensive removal efforts from Shiprock Bridge to Mexican Hat in order to remove these fish as they recruit into adulthood will be important in reducing riverwide abundance of channel catfish.

Many unknown factors can make it difficult to detect significant declines in channel catfish abundance or effects of mechanical nonnative removal. While the declines from Shiprock Bridge to Mexican Hat observed in 2013 are encouraging, it is difficult to determine if there was an actual decline in the channel catfish population or if environmental conditions during sampling limited catch rates. Turbidity is the biggest factor that can affect electrofishing catch ability through limiting netting efficiency. While we do not have a consistent data set of secchi disc readings for every trip, we can look at the flow of the river for a particular trip in each year for comparison among years. High flows do not always result in higher turbidity in the river; however, rain storms and other monsoonal events cause spikes in flow which is usually a result of washes flashing into the river. The flash flooding of these shale washes usually results in a high sediment load being dispersed throughout the river, resulting in increased turbidity and very poor visibility. Spikes in flow were evident in all four removal trips, including fall monitoring, in 2013. Flows during fall monitoring in 2013 ranged from 1,500 to 9,000 CFS during the nine day trip, whereas in 2012, flows were never higher than 1,100 CFS. It is unknown if the low catch rates observed in 2013 were direct results of the environmental factors such as spikes in flow and increased turbidity or if they were actual population declines in response to mechanical removal. Continued monitoring will enable us to determine if an actual population decline occurred in 2013 or if the lower catch rates were a result of poor sampling conditions throughout the year.

Common carp were once ubiquitous in the San Juan River and during 1991-1997 SJRIP studies were the fourth most abundant fish in electrofishing collections (Ryden 2000). Corresponding with the initiation of intensive removal in each of the three sections, common carp abundance has been greatly reduced to a level of infrequent collection across all studies (Elverud 2010; Ryden 2010). Common carp catch rates in 2013 were < 1.0 fish/hour in all three removal section. Prior to the initiation of nonnative removal in each of the three sections, common carp catch rates during annual fall monitoring were relatively high and showed little variance among years. After intensive nonnative removal began in each section, common carp CPUE immediately declined. Common carp CPUE during fall monitoring has been less than one fish per hour of electrofishing for the last five consecutive years in each of the three sections. These declines may be a result of a combination of factors including intensive nonnative removal efforts, a regulated flow regime resulting in a lack of overbank flow and the waterfall at Clay Hills prohibiting upstream movement of fish out of Lake Powell.

Common carp are one of the world's most damaging and invasive fish. Their establishment in a system can lead to declines in vegetation, water quality and native fauna. Nonnative removal combined with other variables has drastically reduced the common carp population in the San Juan River from one of the most abundant fish in the 1990's to one that is now infrequently collected river wide. This successful management of a very invasive nonnative species is often overshadowed by the trends of channel catfish abundance in the river. While common carp are not predatory, they can still negatively impact native fish communities and affect recovery efforts of endangered. Decreased common carp abundance may limit competitive interactions with native fishes and negative habitat modifications often associated with common carp (i.e. uprooting of aquatic plants causing increased turbidity, possible cause of noxious algae blooms by recycling of nutrients from silt substrates) (Cooper 1987). These decreases in abundance and the subsequent declines in carp biomass may allow for higher utilization of resources by native fishes with limited levels of interspecific competition.

In addition to our goal of removing large-bodied nonnative fishes, intensive nonnative removal trips have contributed to the gathering of information on rare fish distribution and abundance and may be used as a barometer to measure the success of current augmentation programs. The frequency and range of our trips, initially near stocking locations and now riverwide, provide the opportunity to collect large amounts of data on stocked fish and may be used to evaluate the success, or failure, of individual stocking events.

While all rare fish captured in 2013 were considered to be stocked fish, it is encouraging to see hatchery reared fish survive and persist in the river. We continue to capture consistent numbers of adult Colorado pikeminnow throughout the year. Additionally, the documented spawning aggregation of adult Colorado pikeminnow found in the same area two years in a row suggests that the number of sub-adult and adult fish in the San Juan River is reaching numbers that enable them to 'find' each other for spawning. Numbers of Colorado pikeminnow that had a PIT tag at time of capture were reduced in 2013 compared to previous years. It has unknown if these fish are still in the river and go undetected throughout the year or if they have moved out of the system or have perished. However, with the recent work sampling tributaries of the San Juan River and the installation of remote PIT tag arrays in tributaries and the main stem San Juan, we should gain a better understanding on how many PIT tagged fish occupy the San Juan River. Razorback sucker have shown long term persistence in the San Juan River. Fourteen individual fish captured in 2013 had been in the river ten years or more, with one fish persisting in the river 17.8 years. We continued to collect razorback sucker without PIT tags in 2013; however, the majority of fish without PIT tags had scales taken for the study using elemental analysis of scales to determine if they are wild fish or stocked fish.

Mechanical removal of nonnative fishes, primarily channel catfish and common carp, continues to be supported by the SJRIP as one management tool for the recovery of Colorado pikeminnow and razorback sucker. Under the framework of adaptive management, the SJRIP will continue to seek ways to improve the efficacy of nonnative fish removal. Complete eradication of these species is not expected; however, using multiple pass sampling has and is expected to continue to reduce abundance to manageable levels. By reducing abundance and biomass of these species, spatial and trophic interactions with common and rare native fishes should be reduced and may result in improved post-stocking survival of stocked rare fishes. Collecting data on growth, distribution and abundance of rare fishes in conjunction with intensive nonnative fish removal continues to supplement monitoring data of these two species and will assist researchers with future management decisions and assessing progress towards recovery.

ACKNOWLEDGEMENTS

We would like to thank the staffs of New Mexico Department of Game and Fish, Conservation Services Division; Utah Department of Wildlife Resources, Moab Field Station; U.S. Fish and Wildlife Service, Colorado River Project (Grand Junction); Navajo Nation Department of Fish and Wildlife; American Southwest Ichthyological Researchers, L.L.C. and U.S. Bureau of Indian Affairs, Farmington, NM for participating on our intensive nonnative fish removal trips in 2013. Collection permits were issued by New Mexico Department of Game and Fish, Colorado Division of Wildlife, Utah Department of Natural Resources and Navajo Nation Department of Fish and Wildlife. Funding for this work was provided through authorizing legislation for the SJRIP and administered by U.S. Bureau of Reclamation, Salt Lake City, Utah.

LITERATURE CITED

Bliesner, R. and V. Lamarra. 2000. Hydrology, Geomorphology and Habitat Studies. San Juan River Recovery Implementation Program, U.S. Fish and Wildlife Service, Albuquerque, New Mexico.

Brooks, J.E., M.J. Buntjer, and J.R. Smith. 2000. Non-native species interactions: Management implications to aid in recovery of the Colorado pikeminnow *Ptychocheilus lucius* and razorback sucker *Xyrauchen texanus* in the San Juan River, CO-NM-UT. San Juan River Recovery Implementation Program, U.S. Fish and Wildlife Service, Albuquerque, NM.

Cooper, E.L. ed. 1987. Carp in North America. American Fisheries Society. Bethesda, Maryland.

Davis, J.E. 2010. Passive Integrated Transponder (PIT) tagging methodologies for the San Juan Basin Recovery Implementation Program. Final Report for the San Juan River Basin Recovery Implementation Program, U.S. Fish and Wildlife Service, Albuquerque, NM.

Davis, J.E. and B.R Duran. 2009. Non-native species monitoring and control in the upper San Juan River, New Mexico: 2009. Final Report for the San Juan River Recovery Implementation Program, U.S. Fish and Wildlife Service, Albuquerque, NM.

Deroba, J.J., M.J. Hansen, N.A. Nate and J.M. Hennessy. 2005. Evaluating assumptions of mark-recapture studies for estimating angling exploitation of walleyes in northern Wisconsin lakes. North American Journal of Fisheries Management, (25): 890-896

Duran, B.R., J.E. Davis, and E. Teller Sr. 2010. Nonnative species monitoring and control in the upper/middle San Juan River:2010. Progress Report for the San Juan River Recovery Implementation Program. Final Report. U.S. Fish and Wildlife Service, Albuquerque, NM

Elverud, D.S. 2010. Nonnative control in the lower San Juan River 2010. Interim Progress Report for the San Juan River Recovery Implementation Program, U.S. Fish and Wildlife Service, Albuquerque, NM.

Gerhardt, D.R. and W.A. Hubert. 1991. Population dynamics of a lightly exploited channel catfish stock in the Powder River system, Wyoming-Montana. North American Journal of Fisheries Management 11: 200-205.

Helms, D.R. 1975. Variations in the abundance of channel catfish year classes in the upper Mississippi River and causative factors. Iowa Conservation Commission, Iowa Fisheries Technical Series 75-1, Des Moines.

Pitlo, J. Jr. 1997. Response of upper Mississippi River channel catfish populations to changes in commercial harvest regulations. North American Journal of Fisheries Management. 17: 848-859.

Ryden, D.W. 2000. Adult fish community monitoring on the San Juan River, 1991-1997. San Juan River Recovery Implementation Program, U.S. Fish and Wildlife Service, Albuquerque, NM.

Ryden, D.W. 2005. Long term monitoring of sub-adult and adult large-bodied fishes in the San Juan River: 2004. Interim Progress Report for the San Juan River Recovery Implementation Program. U.S. Fish and Wildlife Service, Albuquerque, NM.

Ryden, D.W. 2008. Augmentation of the San Juan River razorback sucker population: 2007. Interim Progress Report for the San Juan River Recovery Implementation Program. U.S. Fish and Wildlife Service, Albuquerque, NM.

Ryden, D.W. 2009. Long term monitoring of sub-adult and adult large-bodied fishes in the San Juan River: 2008. Interim Progress Report (Draft) for the San Juan River Recovery Implementation Program. U.S. Fish and Wildlife Service, Albuquerque, NM.

Ryden, D.W. 2010. Long term monitoring of sub-adult and adult large-bodied fishes in the San Juan River: 2010. Interim Progress Report for the San Juan River Recovery Implementation Program. U.S. Fish and Wildlife Service, Albuquerque, NM.

San Juan River Recovery Implementation Program. 2013. Long Range Plan. U.S. Fish and Wildlife Service, Albuquerque, NM.

San Juan River Basin Recovery Implementation Program. 2012. San Juan River Basin Recovery Implementation Program Monitoring Plans and Protocols. San Juan River Basin Recovery Implementation Program, U.S Fish and Wildlife Service, Albuquerque, NM.

SPSS. 2004. SPSS 13.0 Brief Guide. SPSS Inc., Chicago, Illinois, U.S.A. 231 pp.

U.S. Fish and Wildlife Service. 2002a. Colorado pikeminnow (Ptychocheilus lucius) Recovery Goals: amendment and supplement to the Colorado Squawfish Recovery Plan. U.S. Fish and Wildlife Service, Mountain-Prairie Region (6), Denver, Colorado.

U.S. Fish and Wildlife Service. 2002b. Razorback sucker *Xyrauchen texanus* Recovery Goals: amendment and supplement to the Razorback Sucker Recovery Plan. U.S. Fish and Wildlife Service, Mountain-Prairie Region (6), Denver, Colorado.

Zar, J.H. 1996. Biostatistical Analysis. 4th edition. Prentice-Hall, Upper Saddle River, New Jersey.

Appendix A-1. Mean discharge, effort and total count of major species collected during intensive non-native removal efforts from PNM Weir to Hogback Diversion, 2013. Species listed by the first three letters of the Genus and first three letters of Species (i.e. *Ptychocheilus lucius* = *Ptyluc).* [1] Mean discharge from USGS gauge #09368000 near Shiprock, New Mexico.

Trip	Discharge[1] (ft^3/sec)	Effort (hours)	*Ptyluc*	*Xyrtex*	*Ictpun*	*Cypcar*	*Micsal*	*Ameiurus spp*	*Saltru*
July 16-18	1,484	16.1	21	223	33	6	-	4	9
November 12-14	690	15.2	40	453	9	13	-	2	6
Totals		**31.3**	**61**	**676**	**42**	**19**	**-**	**6**	**15**

Appendix A-2. Mean discharge, effort and total count of major species collected during intensive non-native removal efforts from Hogback Diversion to Shiprock Bridge, 2013. [1] Mean discharge from USGS gauge #09368000 near Shiprock, New Mexico.

Trip	Discharge[1] (ft^3/sec)	Effort (hours)	*Ptyluc*	*Xyrtex*	*Ictpun*	*Cypcar*	*Micsal*	*Ameiurus* spp	*Saltru*
March 19-21	519	26.3	9	437	114	14	0	1	17
July 9-11	593	25.6	44	227	664	28	6	10	4
August 6-8	1402	24.4	45	233	279	16	8	10	2
Totals		**76.3**	**98**	**897**	**1,057**	**58**	**14**	**21**	**23**

Appendix A-3. Mean discharge, effort and total count of major species collected during intensive non-native removal efforts from Shiprock Bridge to Mexican Hat, Utah; 2013. Endangered fish were not collected by upstream boats (n/a). [1] Mean discharge from USGS gauge #09371010 near Four Corners, Colorado.

Trip	Discharge[1] (ft^3/sec)	Effort (hours)	*Ptyluc*	*Xyrtex*	*Ictpun*	*Cypcar*	*Micsal*	*Ameiurus* spp	*Saltru*
Tagging Trip April 11-19	573								
Totals for trip		**92.5**	**50**	**91**	**1,477**	**18**	**0**	**7**	**2**
April 25 – May 3									
Downstream boats		76.7	54	156	1,481	19	1	15	1
Upstream boats	992	81	0	0	1,563	8	0	6	1
Totals for trip		**157.7**	**54**	**156**	**3,044**	**27**	**1**	**21**	**2**
June 20 - 28									
Downstream boats		89.7	149	103	3,605	16	0	22	4
Upstream boats	582	85.3	4	0	3,157	9	1	21	0
Totals for trip		**175**	**153**	**103**	**6,762**	**25**	**1**	**43**	**4**
August 29- Sept 6									
Downstream boats		76.5	146	118	717	18	0	14	0
Upstream boats	821	72.8	9	1	550	11	0	11	0
Totals for trip		**149.3**	**155**	**119**	**1,267**	**29**	**0**	**25**	**0**
****September 19 - 27**									
Downstream boats		44.9	128	108	573	22	0	3	1
Upstream boats	3,312	59	2	0	1,167	22	0	3	0
Totals for trip		**103.9**	**130**	**108**	**1,740**	**44**	**0**	**6**	**1**
Totals (excluding tagging trip)		**585.9**	**492**	**486**	**12,813**	**125**	**2**	**95**	**7**

** Nonnative removal trip conducted in conjunction with annual sub-adult and adult fish community monitoring. Downstream boats sampled using standardized sampling protocols as defined in *San Juan River Monitoring Plan and Protocols (Propst et al. 2006)*. Downstream boats sampled in one river mile increments, with two of every three river miles sampled. When possible, upstream boats sampled all river miles and did not skip the same miles as the downstream boats.